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ON THE NATURE OF MOTION.

SCIENTIFIC philosophy seems to be crystallising about the doctrine of the conservation of energy as its unifying principle. It also seems to be taking the form that forces are the collisions of matter due to motion. This doctrine is not universally accepted but it has been propounded and is already widely accepted and it seems to be growing in favor by reason of its great simplicity and because it furnishes an explanation of many facts and a conceivable explanation for many more, but chiefly from the consideration which is all important, that motion is a real cause of force attested again and again. No other explanation of forces is propounded except as a reification of abstractions inherited from the ontologic age of metaphysics, and still found as an atavism in philosophy.

It is not proposed here to discuss the conservatism of energy nor the kinematic hypothesis that force is the collision of matter in motion, but to assume the theory for the purpose of exhibiting one of its logical consequences.

Every particle of matter known to man is in motion at a high velocity. This wooden ball is in motion about the axis of the earth, about the sun, and also with the sun about some other point in the heavens. The sum of all these motions considered as velocity is unknown, but this may be affirmed with safety, that it is very great. Let us call this the stellar motion of the ball. Its trajectory is composed of at least three great revolutions.

Great as the velocity of the stellar motion is, it is yet small as compared with other motions within the body itself. As now understood the woody tissue is composed of cells, the cells of molecules and the molecules of atoms, all grouped in such a manner by composed motion as to constitute a tissue whose structure is dependent upon molecular motions. That rigidity is sometimes due to motion is well known. Stand by the nozzle of a monitor with four hundred feet of pressure behind the water and watch the stream drive the great boulder away. Strike this stream with a crowbar ; though the iron may bend the stream is unbroken. So we may conceive that rigidity and strength of structure are properties of motion. Let us call this rigidity and structural strength of the woody tissue constitutional motion, whose force is equal to the sum necessary to rend the ball into its constituent atoms. The structural strength is a measure of its constitutional motion which is great as compared with any molar motion observed in the ball. Again, the body exhibits a mode of motion known as heat which is undulatory or vibratory. Something of the velocity of heat is known and it is well known that it is very great as compared with the molar motion observed in the bodies which furnish the heat. Let us call this structural and thermic motion molecular motion.

I roll the ball over the floor and molar motion is exhibited to the vision.

Thus we know of three kinds of motion possessed by the body, but that which is apparent to the unaided vision is but a minute part of the whole. It is evident that it is a very small part of the stellar motion. Let us now see what proportion it bears to the molecular or the constitutional and thermic motion combined. The constitutional motion is measured by the force with which the atoms, molecules, and cells are held together as an organic body. If we attempt to realise this we find it very great, yet we cannot attain to its measure from the fact that it is complicated with the heat motion of the body, but we can obtain some realisation of the sum of the two kinds of motion, though we cannot with certainty divide the cryptic motion between them.

Let the ball be burned and its atoms set free into the air. The disturbance which they cause as they depart is known as light. The light travels at more than a hundred thousand miles per second, that is, it causes a disturbance in the ether which is propagated at that rate by the collisions of the atoms against the particles of ether. There are conditions under which this light may travel at the rate of five hundred thousand miles per second. Now, that these atoms may cause such collisions they must be moving at least at an equal rate at the instant they dissolve from the wooden ball. The constitutional motion of the body transformed into heat and added to its original heat therefore, must equal the light motion which the burning ball produces. Hence we must conclude that the molecular motion of the ball must be at a rate of at least a hundred thousand to five hundred thousand miles per second. Add this motion, whatever it may be, to the stellar motion, whatever it may be, and the sum is very great.

None of these motions are persistently right line motions. It is manifest that the stellar motions are great revolutions. The constitutional motions are also enormously composite. The heat motions, though they may be right-line motions in minute parts, must be composite motion—their paths forever changing, else the body would be dissipated. The molecular motion of each molecule in the body, though proceeding at a high velocity, greater than a hundred thousand miles per second, has its path or trajectory confined to the sphere of the molecule itself. Considering this molecular motion, not in relation to stellar motion nor in relation to molar motion, but wholly in its relation to the particles of the molecule, it must be highly composite. The molar motion of the rolling ball is revolution and translation, but it is so small as compared with the others that it hardly seems worthy of consideration. Still it must not be neglected, for this is the motion the characteristics of which we have set out to explain. Let us once more consider what has been said. The atoms of the ball when all their motions are analysed and summed prove to have enormous velocities in enormously composite paths compared with which the molar motion of the ball on the floor sinks into insignificance.

Every particle in the wooden ball rolling on the floor has stellar motion, molecular motion, and molar motion. Consider one of these particles moving with the three kinds of motion and we realise that its velocity is very great, and that the path which it traverses is greatly composite. If such a particle had its composite path straightened into a right-line trajectory, it would in a few seconds pass out of the sphere of the solar system into a region beyond, from whatever point within the system it might start and in whatever direction the right-line path extended. But the molecule remains within the solar system because its stellar motion is composite, and it remains within the ball because its molar motion is composite, and it remains within the molecule because its molecular motion is composite. We have, thus, with regard to every one of the particles of the ball, two facts of motion to consider: First, great velocity, second, great complexity of path.

Every collision of one atom with another must produce an effect upon both. The particles *A* and *B* collide. *A* acts on *B* and *B* on *A*, so that there is both action and reaction in each, and action and passion in each. The action of *A* equals the reaction of *A*. The action of *B* equals the reaction of *B*. The action of *A* equals the passion on *B*, and the action of *B* equals the passion on *A*, thus there is a double correlative.

By such a collision no motion can be acquired and no motion can be lost; for motion is indestructible by our hypothesis; but the effect of the collision will certainly be a change in direction or deflection. We know of deflection, but is there something else beside deflection? In the current doctrines of physics a something else is affirmed or assumed, that something else being an increase of the velocity of one body accompanied by an equal decrease of velocity in the other, which invalidates the law of motion, that action and reaction are equal; and thus a contradiction is reached. If one of the particles gains motion its action is less than its reaction; if one loses motion its reaction is less than its action. If action and reaction are equal, then neither of the colliding particles can have its velocity increased or diminished. In this double correlative of action and reaction and action and passion the truth must be found and the lurking error discovered.

But the wooden ball was set rolling. Was not motion as velocity added to the ball when it started and subtracted from it when it was stopped?

When the ball was started molar motion began and when stopped that molar motion ended. But we do not suppose that it came out of nothing and evanished in nothing; we resort to preexisting molecular motion to explain it; we say that the molar motion was derived from the molecular motion of the hand that set the ball rolling and that it was transformed into molecular motion in the wall which destroyed the molar motion. In making this explanation we assume that motion went out of the hand into the ball and then out of the ball into the wall. Is this true? Was the velocity of the molecular motion in the hand diminished and the velocity of the molecular motion in the wall increased? If so, action and reaction are not equal.

Did velocity go out of the hand into the ball, or was the mode of motion existing in the ball changed? Did velocity go out of the ball into the wall or was the mode of motion existing in the wall changed? If the law of action and reaction is valid, when the change was made upon the ball by the hand, an equal change was made upon the hand by the ball. Neither of them lost velocity by the changed form. When the ball struck the wall neither ball nor wall lost velocity, but both changed their mode of motion by collision. The form or mode of motion was affected, the quantity of motion as velocity was unaffected. But there was a change in the hand, in the ball, and in the wall. In what did that change consist? We know that in part at least it consisted in the change of direction. The molecular motions in the hand must have had their directions changed; the molecular motions in the ball must have had their directions changed; in like manner the molecular motions of the wall were changed in direction. This we know: in every collision there is a change of direction in the motion of the particles constituting the bodies colliding. Is this change of direction all? Or is there a transference of velocity so that one loses while another gains? The whole problem is narrowed to this issue—that which we call acceleration is wholly deflection or in part deflection and in part loss and gain—loss of velocity by one and gain by another, and if there is any loss and gain then action and reaction are not equal.

Imagine a man walking in a circle of ten feet radius. The sphere of his motion is within that circumference. He may soon walk a mile and never be more than thirty feet away from any given point in the circumference; change his direction so that his path is straightened, and he may soon be a mile away. A body of men walking in a circle remain together as a body within the circumference of the circle. Instantaneously change their paths to parallel right lines, and as a body they may soon be a mile away and still in a circle. In the same manner the molecules of the wooden ball are in motion within the theatre of the ball, so that they do not pass beyond its boundaries, yet impose upon each molecule a change of direction in such manner that they all move a little more in one course and a translation of the ball is effected by a change of direction in the motion of its constituent molecules, and the ball still remains as an incorporate body. It is thus possible to explain molar motion of the ball as a change in direction of the motion of its molecular parts, without assuming an increase of velocity in the parts. By such an assumption the molar motion perceived by vision would be legitimately derived from the molecular motion known by reason; no motion would be created or destroyed, and action and reaction would remain equal, while the apparent molar motion would be explained by a change of direction very minute as compared with the composite paths of the several molecules. It is thus that when we consider the total motions of the atoms of the ball even when it is shot from a cannon's mouth, an inconceivably small change of direction in the motion of every atom as compared with the complexity of its path would fully account for the flight of the ball as projected by dynamite.

Now we know of deflection and that it arises from collision, and we know of no other change in motion. Acceleration as increase of velocity cannot in the nature of the case be demonstrated, for it may be always explained as deflection and can never be explained without deflection; and to assume acceleration as increase of velocity is to contradict the law that action and reaction are equal. If acceleration is explained as deflection it is explained by referring it to a known cause and adequately explained.

The pendulum swings. Its molar motion seems to come to rest. Gradually it moves again on its return path, and the swing is repeated over and over. Apparently its motion is destroyed and created at every vibration, and this is true of its molar motion. But now we must consider that this seen vibration is but a part of its motion. It has stellar and molecular motion. It is a body composed of many atoms, and the molar motion constitutes but a minute part of the total motion. To properly understand its motion of swing we must discover the relation of this minute part to the grand total. Are we sure that velocity is added to the grand total, or is it a change in the direction of the multiform motions of the body, stellar, constitutional, and thermic, of inconceivable minuteness? For it is possible thus to explain the molar motion. We know that the direction of motion can be changed, and we resort to a known cause in thus explaining it. If we attempt to explain it as an increase in velocity we resort to an unknown cause, for it can never be shown that any change in motion is increase of velocity. If the third law of motion is true our explanation is valid.

But the pendulum was set in molar motion by a collision with the hand, and it returns to apparent rest after many collisions with the molecules of the air. That which was made to appear to the vision as molar motion was derived from collision and is lost in collision. Did anything but collision go out of the hand through the pendulum and into the air? Was the velocity of the air-particles permanently increased thereby and the velocity of the hand-particles permanently diminished thereby? This is the problem we are seeking to solve. If motion left the hand and was discharged into the air, then motion may be dissipated and the first law of motion is an illusion ; but if the changes wrought are explained as collisions, then the law remains and the illusion is one of the sense of vision, easily and simply explained ; for vision takes no cognisance of stellar and molecular motion but only of the molar motion ; and we are compelled to resort to our knowledge of cryptic motion in order to explain the movements of the pendulum as being other than a creation out of nothing and an annihilation into nothing. The explanation by vision is held to be absurd, but if we go beyond vision into the realm of reason we discover that motion can never be created nor destroyed, and we discover still further that action and reaction are equal and that therefore one particle of matter can never yield its motion to another. But vision and reason alike testify to the existence of collision and to the deflection which results therefrom, and hence we are compelled to believe that the apparent motion of the pendulum was not created for the occasion nor borrowed for the occasion but only deflected for the occasion.

Yet, again, this ball of wax is before the fire; the fire gives it heat and the wax is warmed until at last it melts. In the flame constitutional motion is transformed into heat, this heat is radiated through the ether to the wax; the wax itself becomes heated and melts. Does some motion in the gas depart therefrom and pass into the wax? Or do the atoms of the flame collide against the atoms of the ether which again collide against the atoms of the wax in such a manner that the constitutional motion of the wax is transformed into thermic motion? The latter is the explanation which must be given under the hypothesis that motion is persistent in each particle and that collision results only in change of direction. By such explanation we resort to a known cause of change; but if motion itself is transmitted by collision and not simply change of direction, then the law of action and reaction is disproved. The hypothesis of persistent motion in the presence of Newton's third law of motion compels us to the conclusion that collision occurs which results only in change of direction, that the force of heat is collision resulting from motion which persistently inheres in the several particles and which produces an effect upon the particles composing the body heated, and that this effect is a change in the direction of the motion of its molecular particles in such a manner that constitutional motion is transformed into thermic motion.

The motion of the heat in the flame was derived from the constitutional motion of the wood in the grate. Was any motion transmitted? Gather the particles of combustion and we have gases in which motions are discovered equivalent as forces to the structural forces of the wood itself, and these are known as the kinetic forces of the gas. The motion in the wood equals the motion in the gas, for action and reaction are equal.

All explained forces are found to be collisions. Perhaps gravity cannot thus be explained but there are many physicists who believe that it can thus be explained by transforming the theory of La Sage from terms of a fluid to terms of motion. By this explanation gravity would be explained as collision through the interception of collisions by the gravitating bodies. With this explanation the law of gravity is explained and remains valid and there appears to be no substantial reason for the rejection of this gravitational theory.

In all nature we discover these antagonistic forces ; constitutional force and thermic force. If thermic force is greater, constitutional force is less ; the body tends to dissolve or is dissolved. And *vice versa*, if the thermic motion is diminished, the constitutional motion is increased, and in no case can it be shown that one is increased without the other being diminished. The heating of the body therefore adds nothing to its motion but only transforms the motion which it already has into another mode. And *vice versa*, the same is true with any cooling process. When we come to consider all the motions of the body we never have reason to suppose that the total is increased or diminished. No increase or diminution can ever be discovered but we always have substantial reasons to suppose that directions are changed and every change of motion can be accounted for as change of direction, and the third law of motion remains valid.

It thus appears that to interpret acceleration as increase of velocity rather than as deflection is to fall into an illusion of the senses, which unaided deal only with molar forms of motion, and it should be further considered that these molar forms with which the senses deal constitute but an infinitesimal part of the total motions inhering in every body of matter. We know of acceleration as deflection, we do not know acceleration as increase of velocity, and there can be no increase of velocity if the third law of motion is valid. It is well recognised in modern physics that acceleration is sometimes deflection, but it is sometimes held to be increase of velocity, and it is believed that in so far as it is increase of velocity it is not deflection, and in so far as it is deflection it is not increase of velocity. But claim is here made as a universal law that acceleration is deflection.

Let this argument be stated in brief:

First, the tendency of modern investigation is to explain all forces as derived from modes of motion. Great progress has been made in this direction and the theory is widely accepted.

Second, all forces are collisions.

Third, if all forces are collisions the motions from which they result obey the third law of motion, that action and reaction are equal. By this law it is seen that no motion can be lost or gained by any particle of matter.

Fourth, collisions can be transmitted but motion cannot be transmitted.

Fifth, in molar motion there is an apparent creation and annihilation of motion, but this appearance is known to be an illusion. It has been explained as due in part to collision and in part to the transmission of motion. But such transmission contradicts the third law of motion. Acceleration, therefore, must be something else than increase of velocity. It is known to be in part deflection and can all be thus explained; and if the first law of motion is universally valid it is thus explained. Therefore:

1. Acceleration is deflection.
2. The velocity of motion is constant.
3. The direction of motion is variable.
4. MOTION IS INHERENT IN MATTER AND IS NOT IMPOSED UPON IT FROM WITHOUT.

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